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Editor's Note

The arrival of the New Year brings both reflections and resolutions. While many resolutions involve the cessation of bad habits, resolutions to enrich our lives are much easier to commit to. This year, consider the rewards of participating in the IES Continuing Education Program. The program offers small classes, knowledgeable instructors, and a large selection of courses.

In this issue, learn about how terrestrial matter fuels the aquatic food chain. In a recent *Nature* paper, Institute scientists reveal that lake organisms are dependent on carbon generated on the shoreline. While fish being made of leaves seems abstract initially, when one abandons strict boundaries between the water and the land, the finding seems logical. Large amounts of terrestrial organic matter enter aquatic systems and consumers depend on this food source.

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Are Fish Made Out of Maple Leaves?

Many of us learned about the aquatic food web in high school. Our teachers explained that aquatic plants form the base of the food web, with the energy they capture from the sun supporting aquatic life, from invertebrates to the largest sport fish. However, a new study shows that aquatic animals are receiving a little help from trees and plants surrounding the lakes they live in.

A recent *Nature* paper authored by Institute of Ecosystem Studies scientists Drs. Michael L. Pace and Jonathan J. Cole, along with colleagues from Wisconsin and Sweden, indicates that a significant part of the aquatic food chain is supported by terrestrial organic matter that originates on the shoreline.

A building block of life, organic carbon is essential to aquatic food webs. In lakes, aquatic plants produce organic carbon by harnessing the sun's energy (photosynthesis); some of this carbon supports the growth of fish and invertebrate populations. Scientists have long suspected that land-grown organic matter is also significant to aquatic life, but this idea is difficult to demonstrate. By tracing the fate of carbon through large-scale lake manipulations, Drs. Pace, Cole, and colleagues, have revealed that in some water bodies the aquatic food web is significantly subsidized by terrestrial organic carbon.

That maple tree leaves may eventually become perch, and that the vegetation around a water body can have profound impacts on the animal life within the body of water, blur the perceived ecological boundaries between aquatic and terrestrial systems. The study confirms that the health of lakes is tied to the condition of their watershed, and that aquatic health can not be assessed without considering surrounding terrestrial systems.

The impetus behind the study, which involved manipulating two Michigan lakes, was a better understanding of the aquatic food chain. Dr. Pace explains, "We wanted to reveal what many ecologists have long thought- aquatic life is partly dependent



IES Research Assistant Matt Van de Bogert and Dr. Jonathan Cole preparing $\text{NaH}^{13}\text{CO}_3$ on Peter Lake

Steve Carpenter

on organic matter produced in the watershed." Using a motorboat and a chemical tracer, Dr. Pace and his colleagues set out to quantify this assumption. "The moral of the story," Dr. Pace comments, "is, yes, fish are made from algae, but fish are also partly made of maple leaves."

Terrestrial carbon and aquatic carbon are virtually identical. To determine the percentage of aquatic life supported by the two types of carbon, the researchers needed to differentiate between them. By applying a baking soda-like solution ($\text{NaH}^{13}\text{CO}_3$) to Lakes Peter and Paul, located at the University of Notre Dame Research Center, they were able to test if lake plant production was sufficient to support resident aquatic life.

Unlike regular baking soda, $\text{NaH}^{13}\text{CO}_3$ has distinct carbon atoms with one neutron more than is typically found in the most abundant form of carbon, ^{12}C . The unique ^{13}C signature of the mixture allows it to be traced when it is taken up by aquatic plants during photosynthesis and then moved through the food web.

The $\text{NaH}^{13}\text{CO}_3$ powder was applied to the lakes over the course of 43 days. Each day, micro-animals, as well as larger animals such as fish, were gathered from the lakes for testing. Using a mass spectrometer, the researchers were able to determine if the lake organisms were using aquatic-produced carbon or terrestrial-produced carbon.

Their findings, that 40-55% of particulate carbon and 22-50% of zooplankton (small

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Managing Deer for Healthy Forests



Scott Bauer, USDA ARS

Whitetail deer buck

In the 1890's white-tailed deer were at the brink of extinction throughout their north-eastern range. Guns and forest clearing led to over-hunting the animals, a popular food source. In 1896, in reaction to their decline, the U.S. Supreme Court declared wild animals property of the state. Stricter hunting regulations, coupled with landowner decisions to prohibit hunting from private property, led to the animals' rebound. Efforts to protect deer may have been too successful; over 100 years later they are so abundant they threaten the ecological integrity of our forests.

If you live in the Northeast, you know that deer are a conspicuous part of the landscape. They are a familiar sight on roadsides, open fields, and even in suburban gardens. Their impact is particularly detrimental, however, in a place few of us are looking—the forest understory. During harsh winters, when desirable foods such as acorns are not available, deer survive by eating the buds of woody shrubs and trees. Persistent bud grazing can kill seedlings and saplings that, in the absence of deer, would grow into future canopy trees.

For the past three decades, IES Wildlife Biologist Raymond Winchcombe has been managing deer on the Institute's 2000-acre (809 hectares) grounds. His goal is to keep the population at a level that ensures a rich forest understory and subsequent forest

regeneration. Composed of young trees, woodland shrubs, and herbaceous plants, understory growth makes the forest floor hospitable to a range of small mammals and woodland birds. When the understory is thinned, nest sites and food sources are lost. "Dutchess County suffers from too many deer. If you compare our forests to forests nearby, within a few miles in fact, you will see stark differences in vegetation. On unmanaged sites, the forest understory is browsed to the point of being barren. At the Institute, there is a lush understory layer, with the young growth needed to sustain both wildlife and the future forest," remarks Mr. Winchcombe.

An annual controlled hunt, held in the fall, serves as the backbone of the Institute's deer management program. Invited by Mr. Winchcombe, participants are screened for shooting and safety proficiency and oriented to the importance of managing deer for forest health. The goal of the hunt, stabilizing the resident deer population, requires hunting female as well as male deer. Participants must abandon a long-held custom, present since the early 1900's,

of sparing does and hunting only bucks. "Does are the reproducers and a reduction in doe numbers leads to a reduction in the next generation of deer. To effectively stabilize a population, does cannot be left out of the equation," explains Mr. Winchcombe.

To assess if the hunt is effective, forest vegetation is surveyed. Each spring Mr. Winchcombe visits 50 forested and old-field sites on the campus and records the impact deer are having on woody plants. Seven major tree species are investigated for deer damage, including the dominant canopy species sugar maple and various oak species. All buds below two meters, the maximum height deer can reach, are examined, with a minimum of 100 buds counted at each site. "By selectively feeding on seedling and sapling buds, deer thwart the growth of young trees," Mr. Winchcombe comments. He adds that, "If 50% or more buds are consistently removed from a sapling or seedling, it will die before reaching maturity."

Avid gardeners know that when winters are hard, their landscape plantings are prone to being eaten by hungry deer. Mr. Winchcombe's vegetation surveys show a similar trend in our forests. Overwinter browsing is tightly linked to total snowfall amounts, with snowy years resulting in more intense browsing. Concerned gardeners can erect a fence to protect their landscape; natural areas are at the mercy of their ungulate residents. This makes managing deer numbers critical. Since the IES managed deer hunts began, deer browse at the Institute has been maintained at a level of 3-15%. "Currently, our deer management program is achieving its goal. Were these numbers to increase significantly, it would indicate the need to reduce more deer," notes Mr. Winchcombe.



Raymond Winchcombe

Taken off-site in an unmanaged forest, this photograph shows lush understory (left) within the fence, but little vegetation where deer can browse.

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It's Never Too Early to Start Planning Your Garden!

Now, when the days are shorter and garden demands are small, is a great time to start thinking about spring plantings. The Institute's Continuing Education Program offers a selection of engaging courses that will enrich the way you interact with your landscape. Winter leaves many of us yearning for a little color, making it a great time to enroll in *Color, Value, Sequence, and Complement*. Starting March 6th, this course, taught by horticulturist Liz Innvar, applies color theory to successful garden design. In *Biodiversity in the Garden*, beginning March 14, participants will discover how to incorporate local birds, butterflies, and small mammals into their gardens. Taught by conservation biologist Cns Winters, students will learn ways to enhance local biodiversity by using native plants to provide food and shelter for wildlife. The Institute's own Judy Sullivan, a native plant specialist, instructs students on how to draw landscaping inspiration from natural plant communities in her March 20th workshop, *Nature vs. Nurture: Designing with Native Plant Communities*. Participants will learn a plant community approach to natural landscaping, with a focus on imitating natural ecosystems, rather than using native plants in traditional displays. On March 21st, landscape designer and historian Marie Stella Byrnes will lecture on *Responsible Gardening for the 21st Century: The Sustainable Landscape*. Encouraging environmentally conscious interaction with the landscape, Ms. Byrnes covers topics such as invasive species, genetic diversity, and wetland restoration. To learn more about registration and fees, call Edith Keck at (845) 677-9643.



Maple Leaves, continued from page 1

animals that live in the water column) in the lakes are derived from terrestrial sources, confirm that lake life is dependent on inputs from outside the aquatic system. The carbon signatures of zooplankton, a dietary staple for many fish, reflect their dependence on both internal plant production and terrestrial organic matter. A future paper will explore the ¹³C signatures found in fish. "Our results," Dr. Cole remarks, "tell us there is not nearly enough aquatic carbon to support these animals; they are dependent on terrestrial inputs."

Dr. Pace comments, "We now have direct experimental evidence to confirm that aquatic food chains are supported not just by the production of plants in the water but also by the production of plants on the land surrounding lakes and ponds. The leaves and organic matter that enter lakes are ultimately incorporated into aquatic animals." These findings challenge traditional views of the aquatic food web and may help inform watershed management. Dr. Pace concludes, "Organic matter from the watershed subsidizes lake food webs allowing more

animal life than if they were simply isolated water bodies."

Jim Morris, the program director of the National Science Foundation's Division of Environmental Biology, which funded the study, comments, "These scientists have found an ingenious method of teasing apart the carbon cycles of lakes." Adding, "Their study findings reinforce the concept that the ecology of lake ecosystems is tightly coupled with the terrestrial landscape." ●

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The success of the program is reflected in the landscape. "Look in the forest and note how far you can see with unimpeded vision, without things growing," Mr. Winchcombe comments, adding that, "Some of our hunters have commented that the understory is getting so thick they cannot see the deer. For me, this is the ultimate sign of success."

To better understand how deer browsing impacts vegetation, Mr. Winchcombe, along with IES Forest Ecologist Dr. Charles D. Canham, built deer exclosures on several sites, both at IES and off-site on two privately owned forests in Dutchess County. While not feasible on large pieces of land, the small fenced plots demonstrate plant growth in the absence of deer. The plots at the Institute confirmed the success of the management program, the results from the other sites underscore the impact of deer over-browsing. At one of the private forests, one can see for hundreds of meters without spotting a seedling growing above knee height. "This site has tremendous seedling density, but persistent deer grazing

does not allow the seedlings to take off," Mr. Winchcombe comments.

At this same site, when the growth in the fenced plots was compared to control plots open to deer browse, the differences were dramatic. Released from grazing pressure, understory vegetation rapidly became dense within the exclosures. Fenced plots had higher numbers of woody plant species, more plant cover, and a higher recruitment of young plants. Oaks and white pines, stunted in the open areas, flourished in the exclosures. "As a result of selective browsing, deer dramatically alter the future landscape by controlling seedling recruitment. Ultimately, their palate is determining what grows in the forest understory," remarks Mr. Winchcombe.

In the absence of an alternative method of controlling deer populations, the ecological health of our natural areas depends upon hunting. Each year, as a result of life-style changes nationally, the number of hunters dwindles. The Institute's deer management program has a high hunter

retention rate, but the average age of participants is over 50 and the recruitment of new hunters is low. "Shrinking hunter numbers is the biggest overall threat to deer management. It is important that those remaining hunters understand and embrace the role they play in deer population management and ecosystem protection. In concert, landowners must also recognize their role in ecosystem protection," Mr. Winchcombe emphasizes.

Deer overabundance is an issue throughout the Northeast. The Institute's deer management program is a successful model of land stewardship and coordinating management strategies with hunters. A lush forest understory and high survivorship of young trees is testimony to the program's success. This spring, when hiking on the Institute's trails, take a moment to notice the understory habitat— from songbirds to chipmunks, it bustles with life. One need only visit comparable private lands without management programs to realize that this is the exception and not the rule. ●

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Newsletter

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Calendar

CONTINUING EDUCATION

The Continuing Education Program is now accepting winter registrations. For information, or to request a brochure, call 845-677-9643 or visit www.ecostudies.org/education/continuing.html. Winter semester programs include:

Gardening

Feb. 15 (1 Sun.): **The Classic Garden**
Feb. 22 (1 Sun.): **Raised Bed Gardening**
Feb. 28 (1 Sat.): **Fundamentals of Turfgrass**
Feb. 29 (1 Sun.): **Native Perennials in the Garden Landscape**
March 1 (4 Mon., 1 Sat.): **Fundamentals of Gardening**
March 6 (1 Sat.): **Color: Value, Sequence, and Complement**
March 6 (1 Sat.): **Designing for Low Maintenance**
March 13 (1 Sat.): **Shrubs for Year Round Beauty**
March 14 (1 Sun.): **Biodiversity in Your Garden**
March 20 (1 Sat.): **Designing with Native Plant Communities**
March 21 (4 Sun.): **Garden Design I**
March 21 (1 Sun.): **Responsible Gardening for the 21st Century: The Sustainable Landscape**

Natural Illustration

March 5 (1 Fri., 1 Sat., 1 Sun.): **Illustrating with Pen and Ink: Intensive Weekend**

HOURS

Winter Hours: October 1 - March 31
Internal roadways and trails closed during deer hunting season, and when snow covered.

Public attractions: Mon.-Sat., 9-4, Sun. 1-4; closed public holidays. The greenhouse closes at 3:30 daily. The Ecology Shop: Mon.-Fri., 11-4, Sat. 9-4, Sun. 1-4. (Please note: The shop is closed Mon.-Sat. from 1-1:30.) Free permits are required and are available at the Gifford House Visitor and Education Center until one hour before closing time.

IES SEMINARS

Free scientific seminars are held at 11 a.m. on Fridays in the auditorium from September until early May.

Feb. 6: **"Tracking ecological processes using stable isotopes."** Dr. Carol Kendall, U.S. Geological Survey.
Feb. 13: **"Predator functional responses and prey defenses."** Dr. Jonathan Jeschke, Institute of Ecosystem Studies.
Feb. 20: **"Paleoecological and modern ecology in the Hawaiian Islands."** Dr. Sara Hotchkiss, Gaylord Nelson Institute of Environmental Studies.
Feb. 27: **"Landscape fragmentation and disease dynamics: prairie dogs and plague in the American West."** Dr. Sharon Collinge, University of Colorado.

THE ECOLOGY SHOP

New items in The Ecology Shop. Woodstock wind chimes; handcrafted brooms from Berea College; slate, copper and river stone items from Vermont; pewter jewelry; new garden tools; and much, much more!
Senior Citizens Days: 10% off on Wednesdays.

VOLUNTEER EDUCATORS

We currently have opportunities for volunteer educators to participate in our Ecology Field Programs for schools. If you are interested in assisting the program leader with programs including Plant Power, Maple Sugaring, Watershed Studies, Water Wonders or Fantastic Forests please contact Susan Eberth at 845-677-7600 ext. 316. Training is provided.

GREENHOUSE

The Greenhouse is a year-round tropical plant paradise and a site for controlled environmental research. The greenhouse is open daily until 3:30 p.m. with a free permit (see HOURS).

MEMBERSHIP

Join the Institute of Ecosystem Studies. Benefits include subscription to the IES Newsletter, member's rate for courses and excursions, a 10% discount on IES Ecology Shop purchases, and participation in a reciprocal admissions program. Individual membership: \$40; family membership: \$50. Call the Development Office at 845-677-7600 ext. 120.

The Institute's Aldo Leopold Society

In addition to receiving the benefits listed above, members of The Aldo Leopold Society are invited guests at spring and fall IES science updates. Call the Development Office at 845-677-7600 ext. 120.

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... IES website: www.ecostudies.org

For information on current IES public events and attractions, visit: www.ecostudies.org/ThisWeek.html.

For garden tips, visit: www.ecostudies.org/gardens.html.